

CIO-SSH16

USER'S MANUAL



**MEASUREMENT
COMPUTING™**

Revision 3
October, 2000

MEGA-FIFO, the CIO prefix to data acquisition board model numbers, the PCM prefix to data acquisition board model numbers, PCM-DAS08, PCM-D24C3, PCM-DAC02, PCM-COM422, PCM-COM485, PCM-DMM, PCM-DAS16D/12, PCM-DAS16S/12, PCM-DAS16D/16, PCM-DAS16S/16, PCI-DAS6402/16, Universal Library, *InstaCal*, *Harsh Environment Warranty* and Measurement Computing Corporation are registered trademarks of Measurement Computing Corporation.

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1.0 SOFTWARE INSTALLATION

Before installing the board, install and run *InstaCal*. This package is the installation, calibration and test utility included with your board. *InstaCal* will guide you through switch and jumper settings for your board. Detailed information regarding these settings can be found below. Refer to the *Extended Software Installation Manual* for *InstaCal* installation instructions.

2.0 HARDWARE INSTALLATION

2.1 INTRODUCTION

The CIO-SSH16 is a signal conditioning accessory board designed to improve the performance of a multi-channel analog input board (such as the CIO-DAS16) wherever channel to channel skew must be minimized. The CIO-SSH16 is shipped with four channels installed but components for additional channels can be purchased for up to 16 channels of signal conditioning. As an accessory, it is mounted external to the PC. It may be placed in the open on your bench top or in a case.

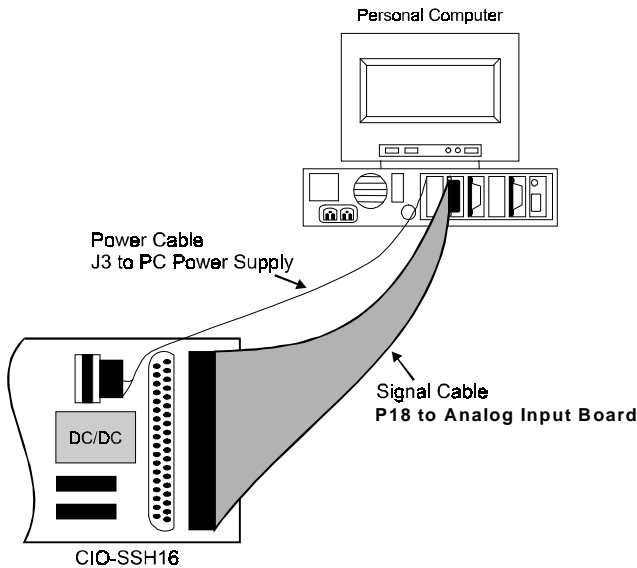


Figure 2-1. Board Cabling

There are two cables used with CIO-SSH16; a signal cable and a power cable. The power cable (C-PCPOWER-10) is supplied with the CIO-SSH16.

The power cable is black with two white MOLEX connectors. One end mates with the J3 connector on the SSH16 and the other mates with any one of the available PC power expansion plugs inside the PC.

The signal cable (C37FF-# or C37FFS-#) is a 37-conductor cable with 37D female connectors at each end. One end plugs into the P18 connector of the CIO-SSH16, the other plugs into the analog connector of a compatible analog input board (such as the CIO-DAS16). (Figure 2-1).

2.2 POWER CABLE

A separate power cable is required because the CIO-SSH16 draws 1 amp from the +5V supply to power the chips and the DC/DC converter which supplies the analog components with +/-15V. This is more current than the C37FF cable should carry. The C-PCPOWER-10 cable included with the CIO-SSH16 provides ample current carrying capability.

The C-PCPOWER-10 power cable has two connectors, one male and one female. The male end has metal pins, the female end, metal sockets.

The male connector will mate with any of the unused PC power expansion plugs inside your PC. It is likely that there are unused plugs attached to wires which come from the PC power supply on your PC. If not, order the C-PCPOWER-Y adapter to add another connection. Plug the male end of the C-PCPOWER-10 power cable into one of the unused power connectors.

Run the C-PCPOWER-10 power cable out the back of the PC. Use an expansion slot or other orifice. If you prefer a connection external to the PC, the BP-POWER adapter is available to bring the power connector out to a bracket that mounts in an unused expansion slot.

WARNING

Use care so that the C-PCPOWER-10 power cable is not pinched by the PC case. If the cable were severed, a serious short circuit would result, possibly damaging your computer.

Power to the SSH 16 is supplied via a four pin MOLEX connector. This connector is the exact mate of the standard PC Power supply expansion power connector. The expansion power connectors are located inside the PC and carry +5V, +12V and Ground. They are used primarily for disk drive power, but, there are more power expansion connectors than you are likely to use (Figure 4-2).

The SSH16 requires 1 Amp of +5 volt power. You may supply this power from the PC, as we recommend, using the cable supplied, or you may use an alternate power supply.

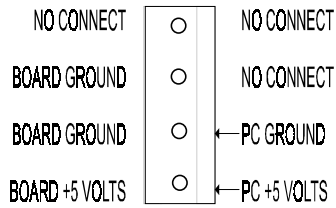


Figure 4-2. Power Connector

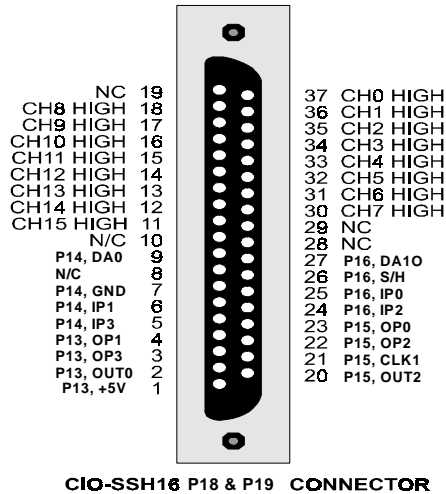
Caution on using alternate power supplies: The analog interface from the SSH-16 to the CIO-DAS16 is a single ended voltage signal connection. As such, it will not reject errors induced by a potential difference between the PC power supply and the alternate supply you use to power the SSH16. Please be certain the PC power supply and alternate power supply share a common ground.

2.3 SIGNAL CABLE

The CIO-SSH16 signal connector is nearly a mirror of the CIO-DAS16 signal cable in 16 channel mode (Figure 1-2). There are two 37D connectors on the CIO-SSH16 wired in parallel. The second, P19, permits daisy chaining signals to other signal conditioning or screw terminal boards.

Use any 37 conductor ribbon cable with female D-37 connectors to connect a CIO-SSH16 to a CIO-DAS16 or other compatible analog input board. The cable length should not exceed 10 feet.

Connect one end of the signal cable to the analog input boards analog connector and the other to the CIO-SSH16 P18 connector.



CIO-SSH16 P18 & P19 CONNECTOR

Figure 1-2 Signal Connector Pin-out

A shielded cable (C37FFS-#) is preferable if EMI or RMI is present with sufficient energy to interfere with noise free measurements. The connection between the CIO-SSH16 and the analog input board is single ended so signals on the cable have no common mode noise rejection.

The signals labeled P13, P14, P15 & P16 (Figure 1-2) correspond to the four screw terminal blocks where other signals coming from or going to your A/D board may be

connected. The nomenclature on the CIO-SSH16 corresponds to CIO-DAS16 signals.

2.4 ANALOG INPUT BOARD SETUP

The analog input board must be configured for single-ended input. If the board you are using with the CIO-SSH16 supports both 8 channel differential and 16 channel single-ended configurations, set the board to 16 channels single-ended.

You may also need to configure a jumper on the analog input board to supply the sample-hold signal to the CIO-SSH16. The SSH16 must have a SAMPLE / HOLD signal in order to trigger the LF398 sample & hold chips. The LF398s sample the input signal on each channel when the analog input board samples channel 0 and each channels signal is held until the next time channel 0 is sampled.

Refer to the users manual for the analog input board you are using for details regarding configuration of the analog input and the sample / hold signal output.

2.5 GAIN SWITCHES

Each amplifier has a quad DIP switch located nearby. The four switches control the gain of one amplifier. The four switches control the gain of one amplifier. The gain settings are additive so a total of 16 different gains (including 1) are possible.

The gain of a switch is added when the switch is to the left and not added when the switch is to the right.

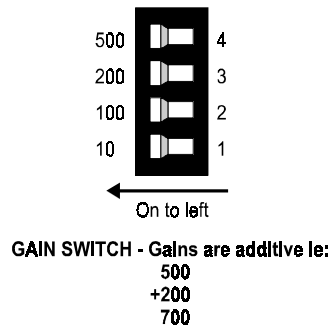


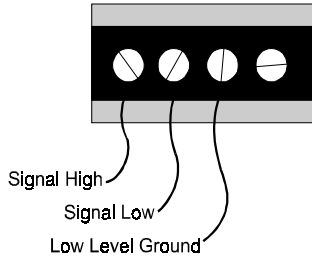
Figure 1-5. Ganged Gain Switch

3.0 SIGNAL CONNECTION

3.1 CONNECTOR DIAGRAM

The CIO-SSH16 inputs are screw terminals which will accept 12-22 AWG wire.

Each channel has a screw terminal for signal high, signal low and ground.



TYPICAL CHANNEL - Differential Input

3.2 ANALOG INPUTS

Analog inputs to the CIO-SSH16 may be connected in two different configurations. In order of complexity, these are Floating Differential and Differential.

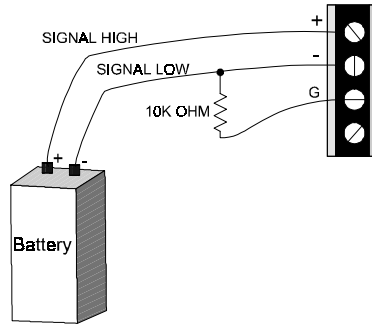
WARNING - PLEASE READ

Measure the voltage between the grounds at the signal source and the PC. Use a volt meter and place the red probe on the PC ground and the black probe on the signal ground. If there is more than 10 volts, do not connect the CIO-SSH16 to this signal source because you will not be able to make any reading. If the voltage is more than 30 volts, DO NOT connect this signal to the CIO-SSH16 because it will damage the board and possibly the computer.

3.3 FLOATING DIFFERENTIAL

A floating differential input is two wires from the signal source and a ground reference resistor (10 Kohms is a typical value) installed at the CIO-SSH16 input. The two signals from the signal source are Signal High (CH# HI) and Signal Low (CH# LO).

The reference resistor is connected between the CIO-SSH16 CH# LO and LLGND pins.



FLOATING DIFFERENTIAL

A floating differential hookup is handy when the signal source is floating with respect to ground, such as a battery, 4-20 mA transmitter or thermocouple and the lead lengths are long or subject to EMI interference.

The floating differential input will reject up to 10V of EMI energy on the signal wires.

WARNING!

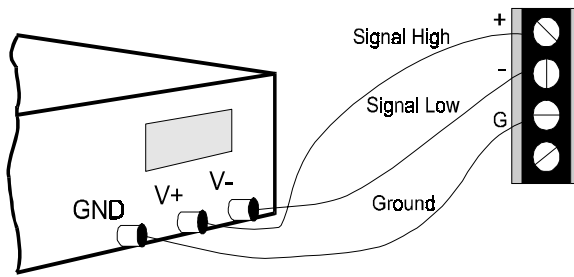
Verify that the signal source is really floating. Check it with a voltmeter before risking the CIO-SSH16 and PC!

3.4 DIFFERENTIAL

A differential signal is three wires from the signal source. The signals are Signal High (CH# HI), Signal Low (CH# LO) and Signal Ground (LLGND).

A differential connection allows you to connect the CIO-SSH16 to a signal source with a ground that different than the PC ground, but less than 10V difference, and still make a true measurement of the signal between CH# HI and CH# LO.

EXAMPLE:



DIFFERENTIAL INPUT

A laboratory instrument with its own wall plug. There are sometimes differences in wall GND between outlets.

4.0 ARCHITECTURE

There are two types of functional elements on the CIO-SSH16; differential amplifiers and a sample & hold chips (LF398). Together they provide differential input and amplification for up to 16 channels of simultaneous sampling signal conditioning. This section contains information on the following subjects:

- Amplification. Gains & signal diagram.
- Sample & Hold. Signal diagram, triggering, timing diagram.
-

4.1 ANALOG INPUT

Analog signal connections are made at screw terminals located along the edge of the board. These screw terminals will accept 12-22 AWG wire and are of the high quality 'clamp' type (Figure 4-3).

Each input channel has three terminals; signal high, signal low and ground.

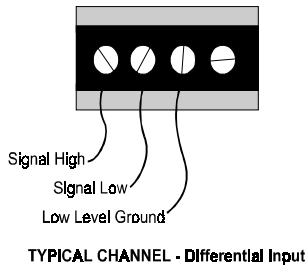


Figure 4-3. Analog Input Connection

The inputs are fully differential. There are two possible signal connections to a differential input which are described in the section on analog electronics.

The screw terminal inputs feed directly into a differential amplifier, part no. IAN110. There are no passive components on the trace between the screw terminal and the IAN110.

4.2 AMPLIFICATION

Each channel is equipped with an INA110 differential amplifier, the gain of which is controlled by a four position DIP switch (S1-S16 for channels 15 to 0; S1=ch15, etc.). The gain settings are additive so a total of 16 different gains (including 1) are possible..

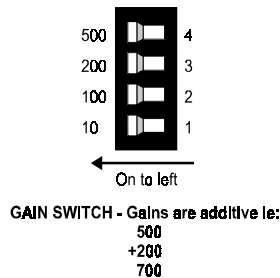


Figure 4-4. Gain Switches

We suggest that the analog input board be configured for a range of +/-5V bipolar or 0 to 10V unipolar and that a CIO-SSH16 gain be chosen that amplifies your sensor signal to that level. Fully amplifying the signal at the CIO-SSH16 provides a high

level signal to the analog input boards single ended inputs, reducing the impact of EMI or RFI along the signal cable between the CIO-SSH16 and the analog input board.

4.3 CIO-SSH16 vs. PROGRAMMABLE GAIN A/D BOARDS

Having a dedicated differential amplifier for every channel produces flexible and powerful data acquisition capability. Data throughput of independent amplifiers exceeds that of A/D boards with single programmable gain amplifiers, even those equipped with a channel/gain queue.

For example, a programmable gain amplifier is often desired so that signals with different ranges can be measured using the A/D converter's full resolution.

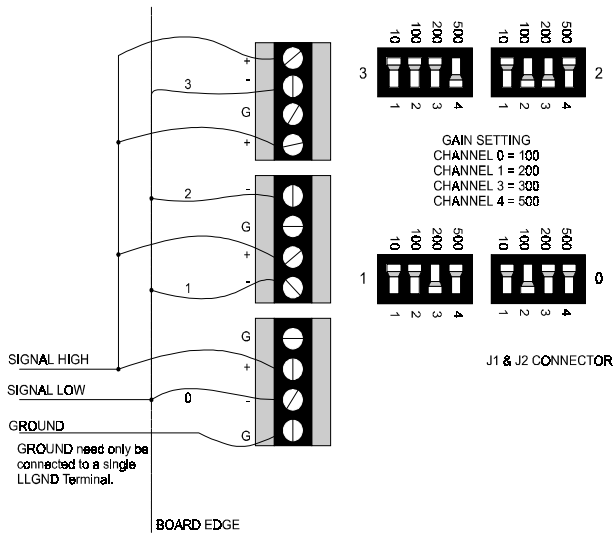
There are two ways to implement programmable gain; the least expensive is to place a programmable gain amplifier on the analog input and locate its control register at one of the A/D board's I/O addresses. The gain is changed by writing to the address. This method works like switch-selectable gain except that the switch is in software. There is one gain for all the analog inputs and changing it is done by writing to a register. High speed acquisition using DMA rules out gain changes made during a sample run. This scheme is inadequate if you want to change gains 'on the fly' and take samples at high speed.

An on-board channel/gain queue is required to enable assigning a different gain to each channel while data is being acquired at DMA speed. This adds considerable cost and programming complexity to the A/D board.

Having independent gain amplifiers on each channel permits selecting optimum gain without any degradation in speed.

Another useful application of programmable gain is to 'tune' the range of the A/D board for the current value of a signal so that optimum resolution possible is obtained. This is done by reading the signal, testing the level and adjusting the gain until A/D board range and the optimum range is achieved.

An alternative and possibly better method of matching the A/D converter to the signal is shown in Figure 4-5. Simply connect the signal to several of the CIO-SSH16 inputs. Set each amplifier to a different gain. Data is collected at full speed!



OPTIMIZING INPUT RANGE - To achieve extra fine resolution.

Figure 4-5. Input Range Optimization

During post-processing analysis, the range which provided the best resolution at any point in time is instantly available.

The cost of a CIO-DAS16 and CIO-SSH16 is less than the cost of an A/D board with a channel gain queue and far less than alternative simultaneous sample & hold schemes. It certainly is more flexible.

4.4 SAMPLE & HOLD

You probably purchased the CIO-SSH16 for its simultaneous sample & hold (S&H) feature, and that was our primary design objective (Figure 4-6). The theory of operation is simple. Sample & hold chips on each channel are synchronized to the analog input boards sample & hold chip via pin 26 of the analog input board (SSH OUT).

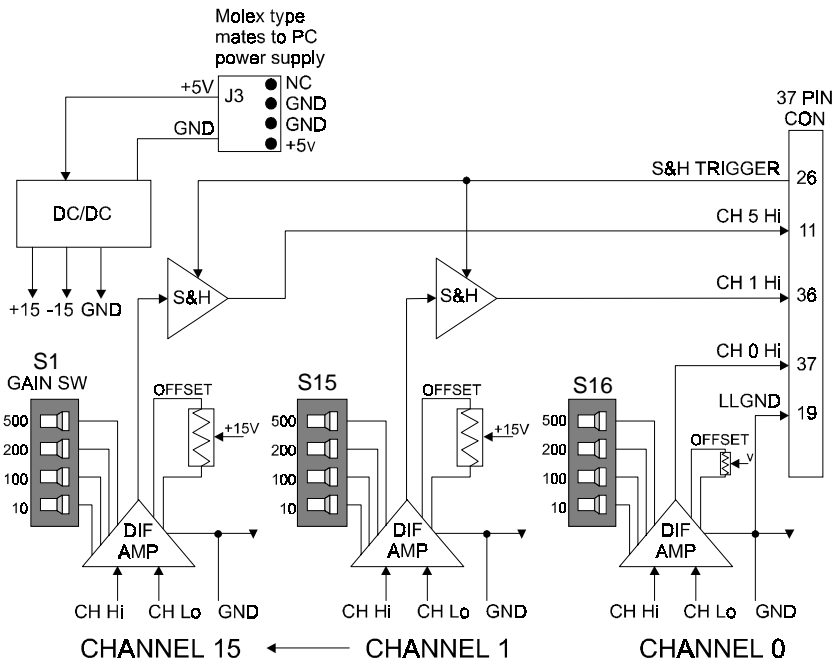
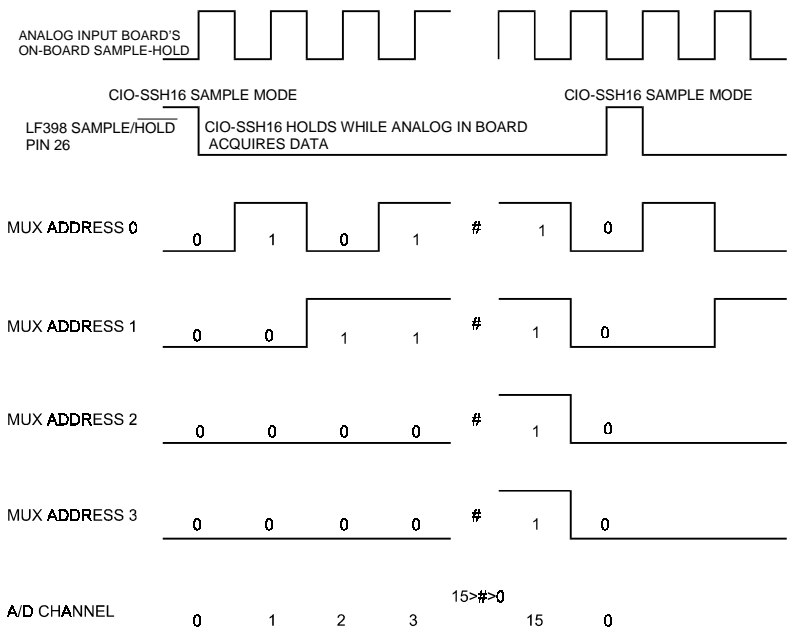


Figure 4-6. Input Amplifiers with Sample and Hold Chips

SSH OUT is synchronized to the analog input boards S&H chip and the channel select MUX. When the analog input board samples channel 0, each of the LF398s on the CIO-SSH16 also samples the signal on its input. Each of the LF398s then switches to HOLD mode and the analog input board acquires this “held” signal from each channel. The CIO-SSH16 remains in HOLD mode until the analog input board samples channel 0 again.



CIO-SSH 16 SAMPLE & HOLD - Timing diagram.

Figure 4-7. Sample and Hold Timing Diagram

Note that Channel 0 of the CIO-SSH16 does not have an LF398 sample and hold chip. That is because there is one sample and hold on the analog input board and it serves as the S&H chip for CIO-SSH16's channel 0. When the S&H on the A/D board is sampling the signal on channel 0, the S&Hs on the CIO-SSH16 are sampling the signals on channels 1 to n. When the S&H on the analog input board enters HOLD, all the S&Hs on the CIO-SSH16 enter HOLD. The S&H chips on the CIO-SSH16 will remain in HOLD mode until the analog input board has acquired all of the channels required and channel 0 is again sampled. In this way, signals for up to 16 channels are sampled simultaneously.

4.5 DROOP RATE

Droop rate is the rate at which the output of the sample and hold 'drips' from the value it was in the instant the S&H entered HOLD mode. The specification on the LF398 is $\pm 100 \text{ uV/ms}$.

A droop implies that reading the output of the S&H as quickly as possible is desirable.

To calculate the effect of the droop rate on the accuracy of your measurement, the range of the signal, the resolution of the A/D converter and the time between HOLD and A/D acquisition are needed. Here is an example.

RANGE CALCULATION

Signal Range	±50 millivolts	
Gain	100	
Amplifier Output	±5 Volts	At full scale

RESOLUTION CALCULATION

A/D resolution	12 bits	1 part in 4096
Volts per bit	2.44 millivolts	10/4096

TIME TO SAMPLE CALCULATION

Number of channels	8	
Sample Rate	4,000 samples/ sec.	
Time between samples	250 microseconds	1/4000
Time from HOLD to CH8	2 milliseconds	0.000250 * 8

DROOP CALCULATION

Maximum droop to CH8	$\pm 0.0001V * 2 = \pm 2$ microvolts.
	Less than 8% of the value of 1 bit.

It is clear from this calculation that droop rate is not a problem even at low sampling rates. The sample rate would have to drop to less than 400 samples/ sec. over eight channels before the droop was detectable by a 12 bit A/D converter.

4.6 ADDING AMPLIFIERS & SAMPLE / HOLD CHIPS

The CIO-SSH16 comes standard with four amplifiers and three sample & hold chips installed.

To add an additional channel, order the two chip set, CIO-SSH-AMP shown here. Twelve CIO-SSH-AMP chip sets may be added for a total of 16 channels (Figure 4-8). You can acquire LF398 S&H and INA110 amps on your own and install them if you wish without voiding your warranty.

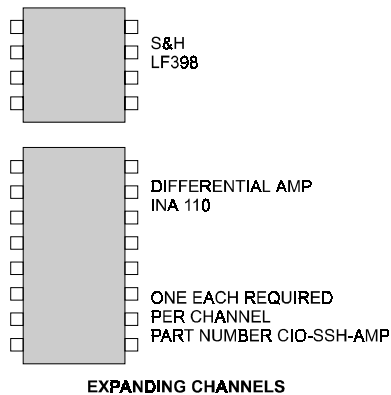


Figure 4-8. CIO-SSH-AMP Chip Set

5.0 SPECIFICATIONS

Typical for 25°C unless otherwise specified.

Power consumption

+5V 1.0A typical, 1.25A max

Analog input section

Input amplifier type INA110
Number of channels 16 differential
Input range $\pm 10V$
Gains X1, X10, X100, X110, X200, X210, X300, X310,
X500, X510, X600, X610, X700, X710, X800,
X810

Gain error

Gain = 1 0.02% max, 0.002% typical
Gain = 10 0.05% max, 0.005% typical
Gain = 100 0.1% max, 0.01% typical
Gain = 200 0.2% max, 0.02% typical
Gain = 500 0.5% max, 0.05% typical

Nonlinearity

Gain = 1 0.005% max, 0.0005% typical
Gain = 10 0.01% max, 0.001% typical
Gain = 100 0.01% max, 0.002% typical
Gain = 200 0.01% max, 0.003% typical
Gain = 500 0.02% max, 0.005% typical

Temperature coefficient

Gain = 1 ± 20 ppm / Deg C
Gain = 10 ± 20 ppm / Deg C
Gain = 100 ± 40 ppm / Deg C
Gain = 200 ± 60 ppm / Deg C
Gain = 500 ± 100 ppm / Deg C
Offset $\pm 15mV$ / Deg C

Calibration Offset manually adjustable to 0
Common Mode Range $\pm 10V$
CMRR @ 60Hz 90 dB
Input leakage current 200 pA
Absolute maximum input voltage $\pm 35V$

Sample / hold section

Sample / hold type	LF398
Aperture time	250 ns max, 150 ns typical
Aperture uncertainty	50 ns typical
Acquisition time	10 μ s max
Temperature coefficient	4 ppm/ $^{\circ}$ C
Droop rate	$\pm 100 \mu$ V/ms
RMS Noise (10 kHz to 100 kHz)	10 μ V
Current Drive	± 5 mA
Output coupling	DC
Output impedance	0.1 Ohms max
Miscellaneous	TTL high level for sample mode, TTL low level for hold mode

Environmental

Operating temperature range	0 to 60 $^{\circ}$ C
Storage temperature range	-40 to 80 $^{\circ}$ C
Humidity	0 to 90% non-condensing

6.0 ANALOG ELECTRONICS

This short introduction to the analog electronics most often needed by data acquisition board users describes the following:

- Voltage dividers.
- Differential vs. Single Ended Inputs.
- Isolation vs. Common Mode Range
- Low pass filters for analog and digital inputs.
- A/D Resolution
- Conversion to Engineering units.
- 4-20 mA inputs
- Noise; sources and solutions.
- Digital interfacing.

Each deals with the impact on measurements made with data acquisition boards. For additional information on the subject of data converters and analog electronics, Radio Shack has written an excellent Op Amp handbook and has an Op Amp experimenters kit.

A more advanced treatment is in the *Analog-Digital Conversion Handbook* (32.95) and the *Transducer Interfacing Handbook* (\$14.50) published by Prentice-Hall.

6.1 VOLTAGE DIVIDERS

If you wish to measure a signal which varies over a range greater than the input range of an analog or digital input, a voltage divider will drop the voltage of the input signal to the safe level the analog or digital input can measure.

A voltage divider takes advantage of Ohm's law, which states,

$$\text{Voltage} = \text{Current} * \text{Resistance}$$

and Kirckoff's voltage law which states,

The sum of the voltage drops around a circuit will be equal to the voltage drop for the entire circuit.

Thus, any variation in the voltage drop for the circuit as a whole will have a proportional variation in all the voltage drops in the circuit (Figure 6-1).

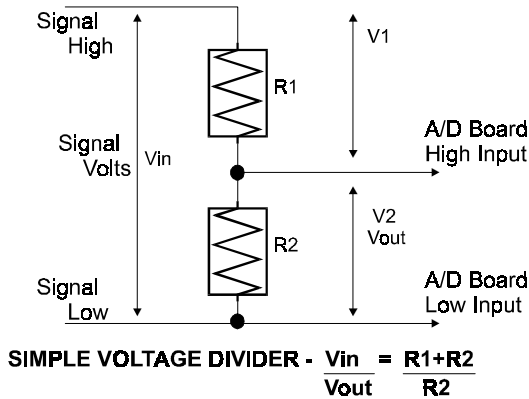


Figure 6-1. Voltage Divider

The object in using a voltage divider is to choose two resistors with the proper proportions relative to the full scale of the analog or digital input and the maximum signal voltage.

Dropping the voltage proportionally is often called attenuation. The formula for attenuation is:

$$\text{Attenuation} = \frac{R1 + R2}{R2}$$

The variable Attenuation is the proportional difference between the signal voltage max and the full scale of the analog input.

$$2 = \frac{10K + 10K}{10K}$$

For example, if the signal varies between 0 and 20 volts and you wish to measure that with an analog input with a full scale range of 0 to 10 volts, the Attenuation is 2:1 or just 2.

$$R1 = (A-1) * R2$$

For a given attenuation, pick a handy resistor and call it R2, the use this formula to calculate R1.

Digital inputs also make use of voltage dividers, for example, if you wish to measure a digital signal that is at 0 volts when off and 24 volts when on, you cannot connect that directly to the CIO-DAS16 digital inputs. The voltage must be dropped to 5 volts max when on. The Attenuation is 24:5 or 4.8. Use the equation above to find an appropriate R1 if R2 is 1K. Remember that a TTL input is 'on' when the input voltage is greater than 2.5 volts.

IMPORTANT NOTE: The resistors, R1 and R2, are going to dissipate all the power in the divider circuit according to the equation $\text{Current} = \text{Voltage} / \text{Resistance}$. The higher the value of the resistance ($R1 + R2$) the less power dissipated by the divider circuit. Here is a simple rule:

For Attenuation of 5:1 or less, no resistor should be less than 10K.

For Attenuation of greater than 5:1, no resistor should be less than 1K.

The CIO-TERMINAL has the circuitry on board to create custom voltage dividers. The CIO-TERMINAL is a 16" by 4" screw terminal board with two 37 pin D type connectors and 56 screw terminals (12 - 22 AWG). Designed for table top, wall or rack mounting, the board provides prototype, divider circuit, filter circuit and pull-up resistor positions which you may complete with the proper value components for your application.

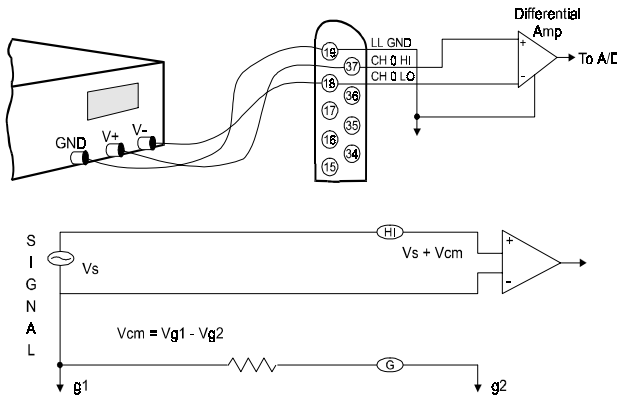
6.2 DIFFERENTIAL & SINGLE ENDED INPUTS

Two type of analog inputs are commonly found on A/D boards, they are differential and single ended. Single ended is the less expensive of the two.

COMMON MODE RANGE

Differential inputs have a common mode range (CMR) (V_{cm}). Single ended inputs have no CMR. Common mode range is the voltage range over which differences in the low side of the signal and A/D input ground have no impact on the A/D's measurement of the signal voltage. A differential input can reject differences between signal ground and PC ground.

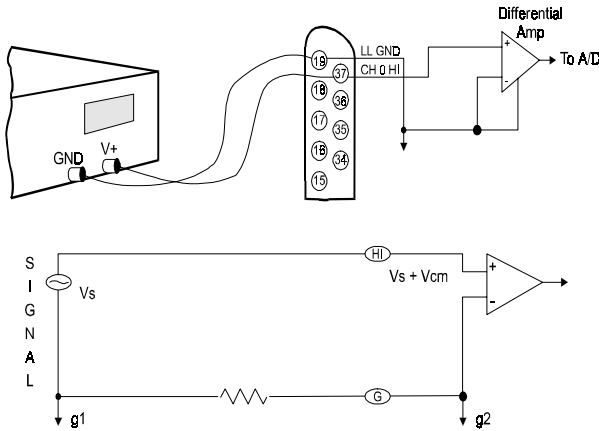
Figure 6-2 shows a differential mode input.



DIFFERENTIAL INPUT

Figure 6-2. Differential Input

A single ended input has no common mode range because there is only one LOW wire, which is assumed to be at the same level at the signal and at the A/D board.



SINGLE ENDED INPUT

Figure 6-3. Single-Ended Input

The maximum difference which may be rejected is the CMR.

For example, the CIO-SSH16 has a common mode plus signal range of 11.5 volts, common mode not to exceed 10 volts.

This specification is illustrated graphically here and will be referred to as Cumulative Signal Range (CSR).

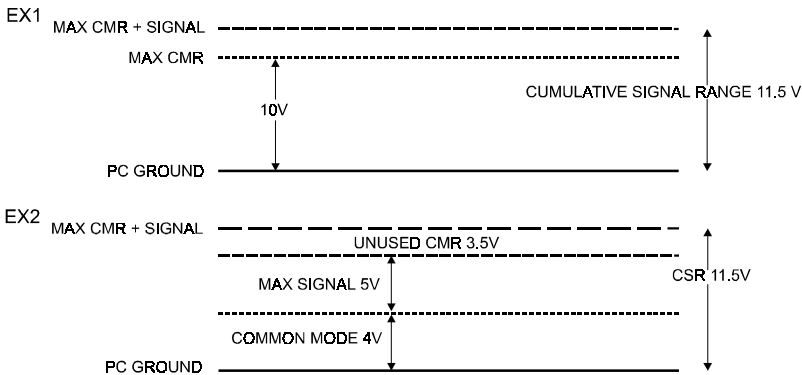


Figure 6-4. CSR

Most manufactures of A/D boards specify the CMR directly from the component data sheet, ignoring the effect of the board level system on that specification. A data sheet of that type might claim 10 volts of CMR. Although this is a factual specification and

the designer of the board (or other EE) would be able to translate that into a systems specification, most A/D board owners are confused or misled by such specs.

6.3 COMMON MISUNDERSTANDINGS

The CMR specification of a differential input is often confused with an isolation specification, which it is not. CMR of 10 volts is not the same as 10 volts of isolation. The graph above shows why.

Also, failure to specify the common mode plus signal system specification leads people to believe that a DC offset equal to the component CMR can be rejected regardless of the input signal voltage. It cannot as the graph above illustrates.

When is a differential input useful? The answer is whenever electromagnetic interference (EMI) or radio frequency interference (RFI) may be present in the path of the signal wires. EMI and RFI can induce voltages on both signal wires and the effect on single ended inputs is generally a voltage fluctuation between signal high and signal ground.

A differential input is not affected in that way. When the signal high and signal low of a differential input have EMI or RFI voltage induced on them, that common mode voltage is rejected, subject to the system constraint that common mode plus signal not exceed the A/D board's CSR specification.

6.4 GROUND LOOPS

Ground loops are circuits ($E=I \cdot R$) created when the signal ground and the PC ground are not the same. Ground loop inducing voltage differential may be a few volts or hundreds of volts. They may be constant or transient (spikes). A differential input will prevent a ground loop as long as the CSR specifications is not exceeded. If ground differences greater than the CMR are encountered, isolation is required.

6.5 LOW PASS FILTERS

A low pass filter is placed on the signal wires between a signal and an A/D board. It stops frequencies greater than the cut off frequency from entering the A/D board's analog or digital inputs.

The key term in a low pass filter circuit is cut-off frequency. The cut-off frequency is that frequency above which no variation of voltage can enter the circuit. For example, if a low pass filter had a cut-off frequency of 30 Hz, the kind of interference

associated with line voltage (60 Hz) would be filtered out but a signal of 25 Hz would be allowed to pass.

Also, in a digital circuit, a low pass filter is often used to filter an input from a switch.

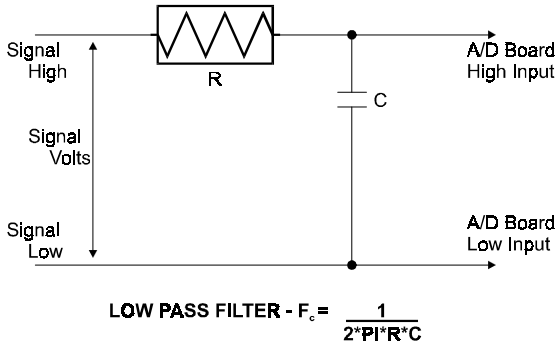


Figure 6-5. Low pass Filter

A low pass filter may be constructed from one resistor (R) and one capacitor (C). The cut off frequency is determined according to the formula:

$$F_c = \frac{1}{2 * \pi * R * C} \qquad R = \frac{1}{2 * \pi * C * F_c}$$

6.6 A/D RESOLUTION & ENGINEERING UNITS

Resolution is specified in bits, such as 8, 10 or 12 bits. The 12 bits are really a power of 2 indicating the number of divisions of full scale the converter can resolve. For example, a 12 bit converter can resolve $(2^{12}) = 4096$ divisions of full scale. If the input of the board were +/- 5 volts full scale, each of the 4095 steps would be equal to 0.00244 volts.

Reading from the A/D converter would be thus:

Converter #	Volts
4095	4.9976
4094	4.9951
4093	4.9927
2048	0.0
1	- 4.9976
0	- 5.0

Resolution is a measure of the ability to differentiate between one voltage and another. Obviously, the more bits of resolution (13 bits = 8192 counts) the more divisions of full scale. The more divisions of full scale, the higher the resolution of the measurement.

6.7 ENGINEERING UNITS

When a program uses an A/D board to acquire data, the data file is filled with numbers like those above.

To translate the A/D numbers back into the engineering units of the original measurement, we need to know:

- The sensor's voltage output per engineering unit.
- The full scale range of the board at the time the measurement was made.
- The resolution of the converter.

Here is an example from the application note on interfacing a Voland TA to a PC found elsewhere in this manual.

The TA measures resistance in grams between +500 and -500 grams.
The voltage output of the instruments is +2.5 volts to -2.5 volts.
The voltage output corresponds to the grams of pressure exactly, so:
+/- 500 grams = 1000 grams.
+/- 2.5 volts = 5 volts.
5 volts / 1000 grams = 0.005 volts per gram.
The A/D was set for +/- 2.5 volts = 5 volts full scale.
5 volts / 4096 counts = 0.00122 volts per bit.
If the number in the file for one reading was 3061, then
 $3061 * 0.00122 = 3.7366$ volts.
 3.7366 volts / 0.005 volts per gram = 747 grams.
Now shift from full scale to +/- scale.
 747 grams full scale - 500 = 247 grams of positive pressure.

It may look like a lot of steps because it is presented that way here for clarity only. It could be expressed as a single equation in a spreadsheet.

6.8 CURRENT LOOP (4-20 mA)

Although the inputs of a CIO-DAS16 board are voltage inputs, it is easy to convert a current to a proportional voltage which may be measured by the CIO-DAS16 board. The current is converted to a proportional voltage by the formula $V=I*R$ (Ohm's law).

For example, if the CIO-DAS16 board is set up to read 0 to 5 volts, then:

$$5 \text{ volts} / 0.02 \text{ Amps} = 250 \text{ Ohm shunt resistor.}$$

So a full 20 mA will register 5 volts and 4 mA will register 1 volt.

To hook up the CIO-DAS16 analog inputs to a 4-20 mA transducer or signal source, place the shunt resistor across the plus and minus terminals or signal wires of the 4-20 mA. Once the resistor is in place, connect the analog input CH# Hi to the plus terminal and the analog input CH# Lo to the minus input.

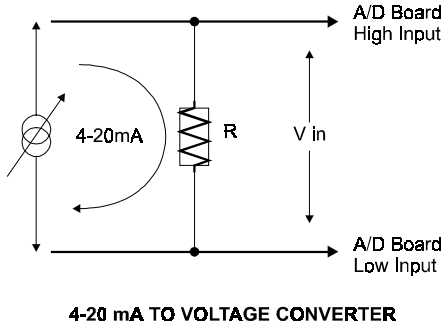


Figure 6-6. Current-to-Voltage Resistor

If they are backward, the A/D reading will be 0 or minus volts. Just reverse the connection.

6.9 NOISE

Noise is unavoidable in PC based data acquisition systems. There is board-induced noise which can be measured by shorting an analog input to ground and taking a series of readings and plotting them in a histogram. There is EMI and RFI-induced noise along the path of the signal wires. There is also noise at the signal source itself. All these sources of noise combine to create a region of uncertainty around the signal value.

Our objective here is to list the sources of noise and give some means to reduce it.

6.9.1 SOURCES OF NOISE

The first source of noise is the board itself. Manufacturers of A/D boards quote component specifications in their data sheets but rarely quote a system specification for general accuracy and noise. The reasons being that the system specification would be less accurate than component specification and that system specifications must also

specify the conditions under which the specification was made. That means the PC, the PC's power supply and the connection to the front end.

Put some very good components on a circuit board and place that board in a PC and the system will be less accurate than the individual components. Some 12-bit A/D boards with the same components as a CIO-DAS16 have as little as nine bits of accuracy, due to board noise.

The system specification for the CIO-SSH16 and CIO-DAS16 is ± 1 LSB. That means that if an analog input is tied to ground and the CIO-SSH16 is on a bipolar scale, the reading will be 2048 90% of the time. The other 10% of the readings will be 2047 and 2049, which is \pm one count (LSB). This is actually not very different from the component specifications.

You can verify this by grounding an analog input channel to LLGND, taking 1000 readings, then plotting a histogram of those readings. (If your histogram is not ± 1 LSB, check the ± 12 V PC power supply voltages.)

6.9.2 SIGNAL WIRE NOISE

Signal wires, especially single-ended inputs, are subject to EMI and RFI, both of which can induce noise on the wires carrying the transducer signal to the CIO-DAS16 board. Fortunately, signal wire noise is often localized and can be reduced by repositioning the signal wire run and/or shielding.

To check for signal wire noise, first, short analog channel 0 to low level ground* at the connector and take 10,000 samples and plot the histogram. This is the best the signal can be and is what you will try to achieve with the signal wires in place.

After you have an ideal case histogram, remove the short between analog input 0 and low level ground. Attach the signal wires to the CIO-DAS16 board inputs and run them to the sensor. Do not connect the sensor yet, just short the analog input(s) to LLGND.

Take data for the histogram and compare it to the best case data taken previously. If it shows noise, you can try to eliminate the noise by doing the following:

- Move the signal wires, trying to locate a 'quiet' run.
- Use a shielded twisted pair as the signal wire. Attach the shield at the PC end only. If the shield is attached at both the PC and the sensor it may create a ground loop and add to signal interference.

6.9.3 SENSOR NOISE

When the signal wires have been tested and characterized for signal quality, connect the sensor and provide a known level to the sensor (ice bath for temp., etc.) then take data for the histogram plot. If additional noise has been introduced by the sensor which exceeds the sensor specifications, you can try moving the sensor or electrically isolating it from the device it is measuring.

6.9.4 SMOOTHING DATA

It is not always possible to eliminate all noise, especially with very low level sensors, but noise looks terrible when plotted and can raise doubts about otherwise excellent data. There are two simple ways to eliminate noise from the data:

1. Apply a moving average to the data if you want to retain the same apparent accuracy.
2. Remove the information from the noisy range. For example, if a 12 bit A/D converter is at +/- 5 volts (10 volts full scale) then one LSB = $10 / 4096 = 0.00244\text{mV}$. If your system is inducing +/- 0.007mV of noise (+/- 3 counts), round all the readings by +/- 3 counts. In this way the reading's value reflects the true accuracy of the system.

For your notes.

EC Declaration of Conformity

We, Measurement Computing Corp., declare under sole responsibility that the product:

CIO-SSH16

Part Number

Description

to which this declaration relates, meets the essential requirements, is in conformity with, and CE marking has been applied according to the relevant EC Directives listed below using the relevant section of the following EC standards and other normative documents:

EU EMC Directive 89/336/EEC: Essential requirements relating to electromagnetic compatibility.

EU 55022 Class B: Limits and methods of measurements of radio interference characteristics of information technology equipment.

EN 50082-1: EC generic immunity requirements.

IEC 801-2: Electrostatic discharge requirements for industrial process measurement and control equipment.

IEC 801-3: Radiated electromagnetic field requirements for industrial process measurements and control equipment.

IEC 801-4: Electrically fast transients for industrial process measurement and control equipment.

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